



# OPERATION MANUAL

## EARTH RESISTANCE METERS

### MRU-105 & MRU-106





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# 1 Preface

Thank you for choosing our MRU-105/MRU-106 earth resistance meter. The MRU-105/ MRU-106 meters are a modern, high quality measurement devices that are easy and safe to operate. Before use, please familiarise yourself with this manual. It will help you avoid any measurement errors and operating problems.

In this instruction we use three types of warnings. They are shown as a framed text and describe possible hazards for either the user or the device. Texts that start with the word "**WARNING:**" describe a life threatening or hazardous situation that can result if the instructions are not followed. Wherever a "**CAUTION!**" exclamation opens the framed text, it describes a situation where non-adherence to the manual can result in damage to the meter. Possible problems that may occur are preceded with the word "**Note:**"

**WARNING:**

**Before starting to use the device, please read carefully this manual, always follow all health and safety guidelines and comply with manufacturer's recommendations.**

**WARNING:**

**MRU-105/MRU-106 meters are designed to test earth resistance and ground resistivity. Using the device for purposes other then those described in this manual can cause an injury to the operator and/or can damage the device.**

**WARNING:**

**MRU-105/MRU-106 meters can be used only by qualified personnel who are certified to work with electrical installations. Operating the instrument by a person who is not qualified, can result in a hazardous situation and/or can cause damage to the meter.**

**Note:**

**The manufacturer reserves the right to introduce changes to device's design, accessories and specifications.**

**Note:**

**An attempt to install drivers in 64-bit Windows 8 may result in displaying "Installation failed" message.  
Cause: Windows 8 by default blocks drivers without a digital signature.  
Solution: Disable the driver signature enforcement in Windows.**

## 2 Introduction

This manual describes the MRU-105 and MRU-106 devices. We recommend that you familiarize yourself thoroughly with the contents of this manual in order to avoid errors that can result in a safety hazard or in an incorrect assessment of tested installations. More information related to safety issues can be found in chapter **3 – Safety**. Before you use the device for the first time, read carefully chapter **6 – Before You Start**. If the device causes any problems, refer to chapter **8 – Trouble Shooting**. All information on how to use the device is located in chapter **7 – Operations**.

## 3 Safety

MRU-105/MRU-106 instruments are designed to test the safety of electrical installations. Therefore, to ensure that the instrument is used correctly, and that obtained results are reliable, you need to adhere to the following rules:

- Before starting to use the meter, you have to become thoroughly familiar with this manual.
- The device should be operated only by persons holding appropriate qualifications and who attended appropriate occupational health and safety training.
- It is not acceptable to:
  - Use the meter that is damaged in any way
  - Use leads with damaged insulation
  - Use the meter stored in inappropriate conditions (e.g. high humidity) for a prolonged period of time
- Before commencing a measurement, select the desired mode and make sure that the test leads are connected to the appropriate terminals.
- Repairs can be performed by an authorised service agent only.

Additional points to remember:

- Symbol „BAT” appearing on the display panel indicates insufficient power supply voltage and signals a need to replace the batteries.
- Measurements obtained while the power supply voltage is too low are burdened with unpredictable additional errors and must not be used to assess the safety of the tested installation.

### CAUTION!

**The meter is designed to operate with noise voltages not exceeding 40V. You must not connect the device to voltages above this value.**

### CAUTION!

**Devices terminals are protected against overload (e.g. when the meter is mistakenly connected to the mains: for any combination of input terminals the protection is up to 276V over a period of 30 seconds.**

### WARNING:

**Using this manual does not exclude the need to comply with occupational health and safety regulations and with other relevant fire regulations required during the performance of a particular type of work. Before starting the work with the device in special environments, e.g. potentially fire-risk/explosive environment, it is necessary to consult it with the person responsible for health and safety.**



## 4 Description and Features

### 4.1 MRU-105/MRU-106 Characteristics

MRU-105/MRU-106 instruments are designed to measure earth resistance and soil resistivity.

Main features of MRU-105/MRU-106 instruments:

- measurement of earth electrodes resistance using a three- or four-pole method;
- soil resistivity measurement with an ability to enter the distance between electrodes (automatic calculation and display of the resistivity in  $\Omega\text{m}$ );
- measurement of resistance using a two- or four-pole method;
- ability to perform measurements of multiple electrodes using a three-pole method without disconnecting earth electrodes tested (using clamps);
- checking the noise voltages (alternating and direct current) and automatic termination of the resistance measurement when the noise is too high;
- checking earth electrodes resistance before commencing the measurement to provide proper measurement accuracy;
- memory for 300 measurements and an ability to transfer the data to a PC;
- a large, clear, backlit LCD display;
- ergonomic design;
- power supply – rechargeable NiMH battery pack or disposable R14 batteries;
- built-in battery charger;
- battery status monitor;
- Automatic shut down (AUTO-OFF) when the device not in use;
- Hermetic, housing with a flip-up lid;
- Robust and ergonomically designed accessories supplied in a carry case.

### 4.2 Standard Accessories

The device is supplied in a kit that contains:

- MRU-105/MRU-106 meter,
- Set of measuring conductors:
  - 50-metre yellow reeled cable – **WAPRZ050YEBBSZ**,
  - 25-metre red reeled cable – **WAPRZ025REBBSZ**,
  - 2.2-metre black cable with pin plugs – **WAPRZ2X2BLBB**,
  - 1.2-metre yellow cable with pin plugs – **WAPRZ1X2YEBB**,
  - Black crocodile clip K01 – **WAKROBL20K01**,
  - Yellow test prod with banana socket – **WASONYEOGB1**
- 30-cm earth contact probes (MRU-105 and MRU-106 - 2 pcs.) – **WASONG30**,
- L2 carrying case for the meter and its accessories – **WAFUTL2**,
- 5 batteries R14,
- Service manual,
- USB cable – **WAPRZUSB**,
- Meter carrying harness – **WAPOZSZE1**,
- Calibration certificate.

### 4.3 Optional Accessories

Additional accessories that are not a part of the standard kit can be purchased from the manufacturer or from suppliers:

- Cable reel – **WAPOZSZP1**,
- 80-cm earth contact probe – **WASONG80**,
- Anvil clip – **WAZACIMA1**,

- L3 carrying case for 80-cm probes – **WAFUTL3**,
- Measuring clamps C3 – **WACEGC30KR**,
- NiMH 7.2V 3Ah battery pack – **WAAKU05**,
- Calibration certificate – **LSWPLMRU105 (106)**,
- SONEL “Electric measurements” software aiding preparation of complete measurement documentation – **WAPROSONPE3**,
- Software generating drafts, electric installation schematic diagrams SONEL Schematic – **WAPROSCHEM**,
- Measurement calculation software SONEL PE Calculations – **WAPROKALK**.

#### 4.4 Terminals and Keypad Layout

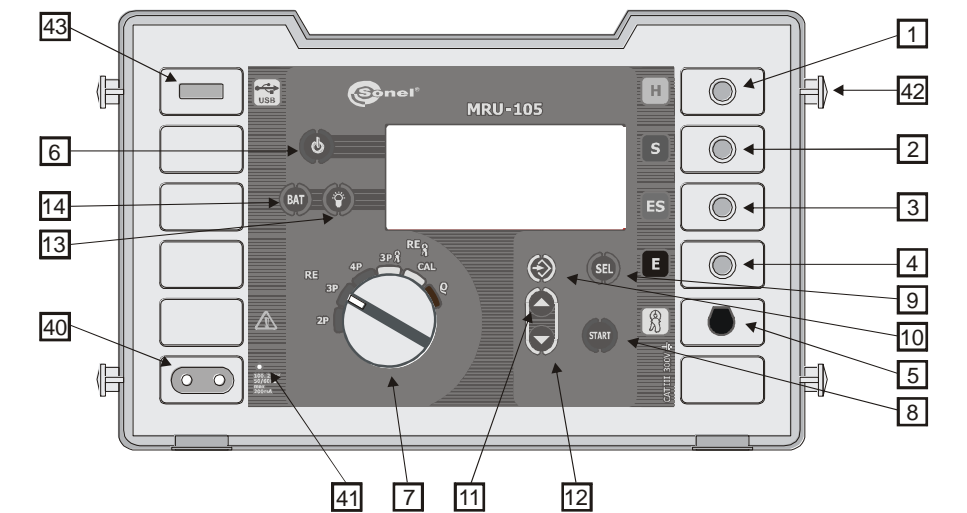


Figure 1: Front panel of the MRU-105 and MRU-106 meter

##### 4.4.1 Terminals

CAUTION!

The meter is designed to operate with noise voltages not exceeding 40V. You must not connect the device to voltages above this value.

- 1

**Test terminal H**  
Terminal to connect the current electrode during resistance and resistivity measurements
- 2

**Test terminal S**  
Terminal to connect the voltage electrode during resistance, earth resistance and resistivity measurements.

### **3 Test terminal ES**

Terminal to connect an auxiliary voltage electrode during soil resistivity measurements using a four-pole technique. This terminal is also used for resistance measurements using the two- and four-pole techniques.

### **4 Test terminal E**

Terminal to connect tested grounding while performing earth resistance measurement and to connect one of the outer-most electrodes while measuring soil resistivity.

### **5 Clamps terminal**

Terminal to connect test clamps for testing multiple electrodes without disconnecting the earth electrode tested.

### **40 Mains power supply socket**



Socket for connecting power supply for the battery charger.

### **43 USB port**

Communications port to connect a USB cable.



## **4.4.2 Keypad**

### **6 Key**

- Turns the power supply on and off. After the power is turned on, the screen displays all digits and symbols (test of the display).
- Holding **14** „BAT” or **10**  key pressed activates special functions:
  - Key **14** „BAT” - battery discharge function
  - Key **10**  - activating data transmission mode

### **7 Rotary mode switch**

Measurement mode selection:

- **Re2p** – two-pole earth resistance measurement,
- **Re3p** - three-pole earth resistance measurement,
- **Re4p** - four-pole earth resistance measurement,
- **Re3p**  - three-pole measurement of multiple electrodes using test clamps,
- **CAL**  - calibration of clamps,
- **p** - measurement of soil resistivity.

### **8 START key**

- Launches the test sequence.
- In the soil resistivity tests:
  - The first key press – entering the distance between electrodes
  - The second press – test sequence launch

### **9 SEL key**

Displaying all values related to the most recent measurement:

- $R_E$  earth resistance,
  - $R_S$ ,  $R_H$  auxiliary electrodes resistance,
- and additionally during soil resistivity measurements:
- Soil resistivity.

### **10 Key (writing to the memory)**

- After completing the measurement (the most recent results are displayed):
  - Activating the memory write mode
  - In the memory write mode – moving the result to the current memory cell

- In the memory browse mode, after cell 00 was selected
  - Erasing the memory contents

**11** Key ▲ (increase)

**12** Key ▼ (decrease)

- In soil resistivity measurements – changing distance between electrodes
- Start the memory browse mode
- In memory browse mode – changing the current memory cell address

**13** Key  (display illumination)

Turns the LCD display illumination on and off.

**14** Key BAT

Displays the battery charging status (in percent points).

## 4.5 Liquid Crystals Display (LCD)

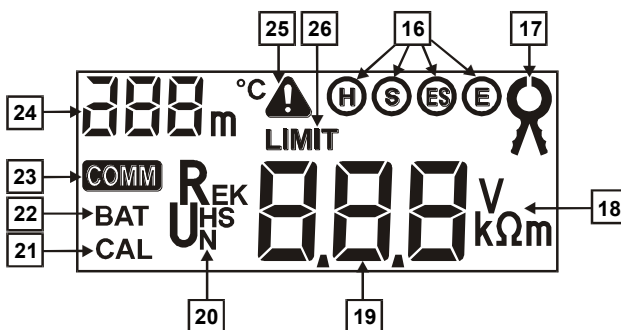



Figure 2: Liquid crystals display of the MRU-105/MRU-106

**16** Test terminals symbols

Indicates the test leads that should be connected for the test

**17**  - clamps

Indicates selection of the multiple electrodes resistance test using clamps or the clamps calibration mode.

**18** Unit and type of the displayed value:

V	volts	- voltage
Ω, kΩ	ohms, kilo ohms	- resistance
Ωm, kΩm	ohm meter, kilohm meter	- resistivity
m	meters	- distance

**19** Measurement result display field

**20** Symbols of the measured and displayed values

- RE – earth electrode resistance;
- R<sub>H</sub> – current electrode (H) resistance;
- R<sub>S</sub> – voltage electrode (S) resistance;
- U<sub>N</sub> – noise voltage

$\epsilon$  – additional error due to probes' resistance [%],

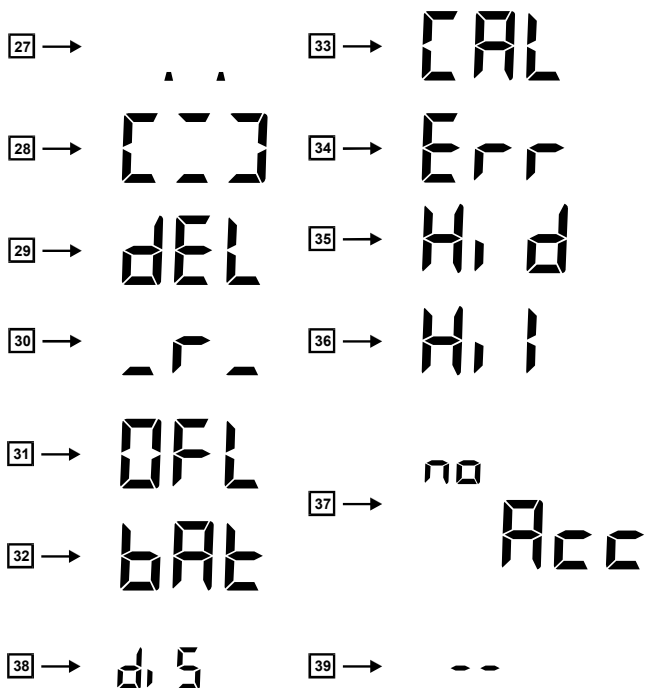


Figure 3: Messages and symbols displayed by MRU-105/MRU-106


- 21 CAL - calibration**  
Indicates selection of the clamps calibration mode.
- 22 BAT – batteries discharged**  
Replacement of the disposable batteries or recharge of the rechargeable batteries required
- 23 COMM – PC data transmission mode**
- 24 Auxiliary display field**
- 25 ▲ - warning**  
Emphasises the importance of the displayed error information – signals a need to refer to the operating manual.
- 26 LIMIT**  
One of the parameters is outside of the range.
- 27 . . (Two dots) – no data in the current memory cell**
- 28 [ ] - writing into the memory**

**29**  - erasing the memory

**30**  - no continuity between electrodes

Resistance between the electrodes, whose symbols are flashing, is too high or the clamps current too low.

**31**  - measurement range exceeded

**32**  - batteries flat

The device is unable to work reliably. It will switch off automatically 3 minutes after the symbol is displayed. Additionally a long audible signal will be produced.

**33**  - successful clamps calibration

**34**  (Error) – an error occurred during test clamps calibration

The symbol may be displayed together with the symbol **LIMIT** and flashing symbols of electrodes or clamps.

**35**  - subsequent measurements dispersed too broadly


Results of subsequent measurements of the same parameter differ considerably.

**36**  - noise current too high

**37**  - NiCd battery pack not present in the instrument

**38**  - NiCd battery pack discharged

**39**  - Currently selected memory cell is being used

**41**  – battery charging indicator

**42**  Lugs to attach carrying straps

## 4.6 Buzzer

### Warning signals:

#### *Continuous audible signal*

- Noise voltage  $U_N$ , greater than 40V.

#### **CAUTION!**

**The meter is designed to operate with noise voltages not exceeding 40V. You must not connect the device to voltages above this value.**

#### *Long audible signal*

- after commencing the measurement by pressing key **8** **START** if the noise voltage exceeds 24V;
- during the measurement no continuity of the test leads detected;
- if any other abnormalities are detected (LCD displays appropriate information);

- completion of the memory erasure operation confirmation;
- after pressing a button that has no function assigned in the currently used mode;
- automatic shutdown (AUTO-OFF) confirmation.

#### **Confirmations an other signals:**

##### *Short audible signal*

- Confirms a key was pressed. Emitted always when the instrument can perform the operation assigned to that key.

##### *Two short audible signals*

- After successful completion of a measurement sequence.

##### *Short signal, short pause and three short audible signals*

- Confirmation that data was successfully stored in the current memory cell.

## **4.7 Test Leads and Probes**

MRU-105/MRU-106 meters are equipped with a set of test leads. The lengths available are: 50m (1x), 25m (2x), and 1,2m (2x).

The 25m and 50m leads are supplied on reels, which can be placed on the test probes to simplify winding and unwinding of the leads. For this reason the reels are equipped with a lock preventing the reel from slipping down the probe.

Among the standard accessories there are two test probes that can be driven into the ground. A test lead is connected to a probe by inserting a banana plug into the socket located in the horizontal section of the probe or through the reel lock – if the lead plug is inserted into the socket on the reel. If, while in the field, the lead plug becomes damaged, the lead can be attached to the probe using an M5 screw after the insulation is stripped from the wire.

To carry out earth resistance measurements it is necessary to obtain an additional 25m test lead and two extra probes.

## **4.8 Test Clamps**

Test clamps are provided as an option for MRU-105/MRU-106 meters. They are used to measure the current in earth resistance tests using multiple electrodes without disconnecting.

## **5 Storage**

When storing the device you should:

- Disconnect all leads from the device, coil the long test leads onto the reels
- Carefully clean all probes and other accessories
- Ensure that the device and all accessories are dry
- Ensure that the disposable batteries are removed (rechargeable batteries are removed and discharged) if the device is not going to be used for a prolonged period of time

## **6 Before You Start**

After the purchase:

- Check the contents of the packaging;
- charge the NiMH battery pack or insert disposable batteries into the meter;
- calibrate the clamps.

## 7 Operations

You need to get familiar with this chapter as it describes test diagrams, testing methods and basic rules to interpret obtained results.

### **CAUTION!**

**The meter is designed to operate with noise voltages not exceeding 40V. You must not connect the device to voltages above this value.**

### **7.1 Preparing the Device for Work**

Before commencing the measurements:

- Make sure that the battery condition will allow you to complete the task;
- Check (while uncoiling the test leads) that the leads insulation is not damaged;
- Check that there is no possibility of leads or electrodes coming in contact with live wires.

### **WARNING!**

**Using test leads that are incorrect or have damaged insulation can cause electrocution.**

### **WARNING!**

**You must not use the device with open or partially closed battery compartment and you must not use any power sources other than those specified in this manual.**

### **WARNING!**

**You must not leave disconnected leads while some of them remain connected to the installation being tested.**

**You must not leave the device unattended while it is connected to tested installation..**

### **WARNING!**

**Do not use a device that was stored for a prolonged period of time in unsuitable (e.g. humid) conditions. If the device was moved from a cold to hot environment, do not carry out any measurements until the device reaches the ambient temperature (approx. 30 minutes).**

### **7.2 Power Supply (rechargeable batteries)**

MRU-105 and MRU-106 is equipped with a battery pack and a charger. The battery pack sits in the battery compartment. Battery charger is installed inside the meter and can be used only with a proprietary NiMH battery pack.



**Note:**

MRU-105 and MRU-106 works only with SONEl NiMH 7,2V 3Ah battery pack. The batteries are supplied not charged. They should be charged before the first use. Using third party NiCd/NiMH R14 batteries will result in a message **22** BAT being displayed. The charger will not work with R14 NiCd/NiMH batteries either.

## 7.2.1 Disposable/Reusable Batteries Replacement

MRU-105 and MRU-106 meter is supplied with either NiMH rechargeable battery pack or a five disposable R14 battery cells (alkaline type battery cells are recommended). Batteries are placed in a recess in the bottom part of the housing.

**WARNING:**

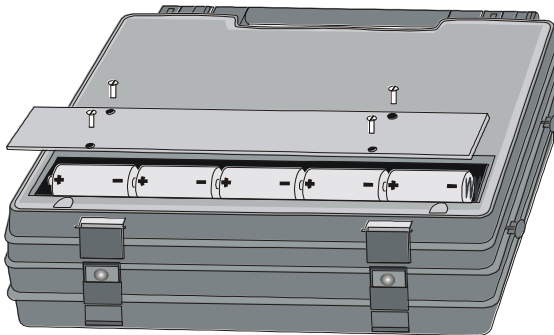
Before replacing of the NiMH battery package remove the measurement leads and the mains cable of the charger out of the sockets). Opening the meter housing with the charger connected to mains can be a cause of an electric shock!

**CAUTION!**

If the batteries leaked inside the compartment, the device should be sent to an authorised service agent.

Discharged batteries are signalled by the message **22** „BAT” or **32** bAt . It is then necessary to replace the batteries with the new ones. To do it, follow the procedure below:

1. Remove all leads from sockets and switch the meter off;
2. Remove four screws securing the battery compartment lid located at the bottom of the housing and remove the battery compartment lid.
3. Replace all batteries. Battery cells (5x R14) or NiMH battery pack type SONEl NiMH 7,2V 3Ah should be inserted in the way indicated on the diagram located inside the recess. Inserting the batteries incorrectly will not damage the instrument or the batteries but will prevent the meter from functioning.
4. Replace the screws securing the lid.



**Figure 4: Opening the battery compartment in MRU-100 Family meters**

## 7.2.2 Charging the Battery Pack

Connecting the power cable to the mains will automatically start the battery charging process while disabling the instrument. The charger recognises whether the battery compartment contains disposable or rechargeable batteries. An attempt to recharge disposable batteries will fail.

NiMH battery pack is charged using a “fast charging” method – this results in charging time to be limited to approximately 3 hours. During the charging process the temperature of the NiMH battery pack, voltage change rate and charging current are monitored. While charging is in progress a green LED diode flashes with the frequency of approx. 1Hz. Completion of the charging procedure is signalled with the LED being solid on.

**Note:**

**If the batteries are almost completely discharged at the beginning of the charging process, the LED will be solid on.**

**Note:**

**Due to faults in the mains supply, the charging process can be completed prematurely. In such case disconnect the device and restart the charging procedure.**

Abnormal conditions (no voltage, damage to the battery pack, overheating etc.) are not signalled. You need therefore, after the charging process is completed, check the battery charge level by pressing **14** **BAT**.

## 7.2.3 General principles of using nickel metal hydride (Ni-MH) accumulators

- If the device is not used for a prolonged period of time, remove the accumulators and store them separately.

- Store accumulators in a dry, cool and well ventilated place, and protect them from direct sunlight. The storage temperature in the case of prolonged storage should be kept below 30°C. If accumulators are stored at a high temperature for a long time, then the chemical processes that are occurring may lead to reduction of their durability.

- NiMH accumulators are generally designed for 500-1000 charging cycles. The accumulators reach their maximum efficiency once they have been formed (after 2-3 charging and discharging cycles). The most important factor that influences the durability of those accumulators is the discharging depth. The deeper is the discharge, the shorter their durability.

- The memory effect in the case of NiMH accumulators is limited. Those accumulators may be additionally charged with no serious consequences. However, it is recommended to discharge them completely after a couple of cycles.

- During storage of Ni-MH accumulators, they are spontaneously discharged at the rate of approximately 30% per month. If accumulators are stored at high temperatures, the process may be accelerated as much as twofold. Lest the accumulators discharge excessively and to avoid the necessity of forming them, it is recommended to charge them from time to time (even if they are not used).

- Modern and fast chargers detect both too low and too high temperature of accumulators and react adequately. Too low a temperature should preclude charging, which might cause irreversible damage

to the accumulator. An increase of the temperature of the accumulator is a signal to finish the process of charging and it is a normal phenomenon. However, charging at a high room temperature not only reduces durability, but also a faster increase of the temperature of the accumulator, which will be not charged to its full capacity.

- Please remember that in the case of fast charging, accumulators are charged to approximately 80% of their capacity and better results may be obtained continuing the process of charging: the charger operates then in the additional charging mode with low current and after next couple of hours the accumulators are fully charged.

- Do not charge or use accumulators at extreme temperatures. Extreme temperatures reduce the durability of batteries and accumulators. It is recommended to avoid placing devices powered from accumulators at hot places. The nominal working temperature must always be observed.

### 7.3 Calibration of Test Clamps

The clamps purchased together with the meter should be calibrated before their use. You can also calibrate them periodically to prevent ageing of components influencing the measurement accuracy. Calibration is recommended after purchasing the clamps (separately) for the meter or after the clamps were replaced with the new ones. The calibration is performed by setting the rotary switch [7] to **CAL**  $\Omega$ . The test terminals „H” [1] and „E” [4] should be connected to each other with a 1.2m test lead and the clamps should be placed over the cable. **Make sure that the cable passes through the middle of the clamps.** After pressing the key [8] **START** the meter determines a adjustment factor for the clamps connected to the instrument. The factor is stored in the memory until the next calibration is performed and regardless of the power status of the meter.

During calibration process the following errors can occur:

Error	Symbol Displayed	Situation
Current is not flowing through the test lead connecting sockets „H” and „E”	[34] $E_{err}$ together with the symbols of sockets in the field [16]	The test lead not connected to proper terminals of the meter or lead broken
Current in the clamps circuit is not flowing	[34] $E_{err}$ together with flashing symbol [17]	Clamps not placed over the lead connected to terminals „H” [1] and „E” [4], or not connected to the instrument
Inconsistent results of subsequent measurements, incorrect clamps type, or the clamps faulty	[34] $E_{err}$ and [25] $\Delta$	Connection of the clamps not stable
The adjustment factor can not be determined	[34] $E_{err}$ and [26] <b>LIMIT.</b>	Current measurement error too high for the adjustment factor calculated; repeat the calibration process

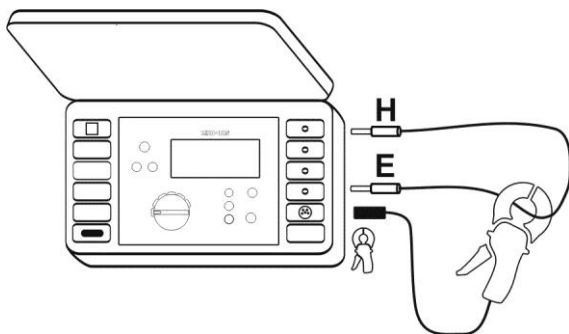


Figure 5. Preparing the instrument for clamps calibration

## 7.4 Conditions for Performing Tests and Obtaining Correct Result


Before starting the measurements, certain conditions have to be fulfilled. The device will automatically block the commencement of any test if any of the following conditions exists:

Situation	Symbols Displayed	Notes
The noise voltage exceeding 24V.	<b>26</b> LIMIT and <b>20</b> U <sub>N</sub>	
The noise voltage exceeding 40V.	<b>26</b> LIMIT and <b>31</b> $\square$ FL	Continuous audible signal generated
No test current detected	<b>30</b> _r_ together with the socket symbol <b>16</b>	Probes required for the test not connected to the device or probes disconnected from the lead
Situation	Symbols Displayed	Notes
Clamps current too low to perform a measurement	<b>30</b> _r_ together with the blinking clamps symbol <b>17</b>	Clamps not connected or too high multiple earth resistance of the tested circuit in comparison to the resultant resistance
Resistance of the test probes exceeds 50 k $\Omega$ .	<b>26</b> LIMIT together with the name of the probe, upon field <b>20</b> of the display unit	Decrease the probe resistance by reinserting it into the ground or by increasing the moisture of the soil around the probe
Measurement range exceeded	<b>31</b> $\square$ FL	

Additionally the meter signals situations in which the result of a measurement cannot be recognized as correct:

Situation	Symbols Displayed	Notes
Measurement error due to resistance of electrodes exceeding 30%	<b>26</b> LIMIT together with the measurement result	Decrease the probe resistance by reinserting it into the ground or by increasing the moisture of the soil around the probe
Batteries flat	<b>22</b> BAT	None of the meter functions is disabled, however the results obtained can be distorted by additional error of unknown magnitude

## 7.5 Performing a Measurement and Obtaining Readings for Individual Components of the Result

After switching the meter on with the key **[6]** , and also after each change of the rotary switch position **[7]**, the LCD displays the noise voltage value. If the voltage exceeds 24 V, it will not be possible to perform the measurement. In this situation it should be checked if the measurement leads are connected to the appliances connected to the mains or if there is no short circuit or arching present in the vicinity of the tested object.

The measurement starts after pressing the key **[8]** **START**. The instrument executes the measurement cycle if none of the conditions, described in chapter 7.4 exists. During the measurement the main result field **[19]** of the LCD displays characters “-” symbolising the progress of the measurement, while in the field **[20]** the currently measured parameter type is shown. After the measurement is completed the measured resistance  $R$  is displayed, together with the resistance of the earth electrode  $R_E$  or the soil resistivity  $\rho$ . The remaining test parameters – the resistance of the test probes  $R_H$  and  $R_S$  – can be displayed by pressing the key **[9]** **SEL**.

### Note:

Displayed value of the additional error [%] is a sum of the probe resistance error and the error of the ratio of the tested circuit resistance to the resultant resistance. Errors are derived from the measured values. If the error calculated in this way exceeds 100%, the symbol OFL is displayed.

The meter automatically selects the measurement range for each mode.

## 7.6 Two-pole Method of Resistance Measurement

Two-pole method is the most common technique for measuring resistance.

1. Connect the test leads to the terminals **[2]** and **[3]** labeled „S” and „ES” respectively (Fig. 6).
2. Set the rotary switch **[7]** to position **RE 2p**.
3. After connecting the resistance to be tested press the key **[8]** **START** – the instrument will start the test cycle.
4. Read the result. The result of the measurement is a sum of the resistance to be measured and the test leads resistance. The impact of the leads resistance on the final result can be eliminated by using a four-pole technique, or by carrying out another measurement with the test leads short-circuited and by subtracting the test leads' resistance from the result obtained originally.

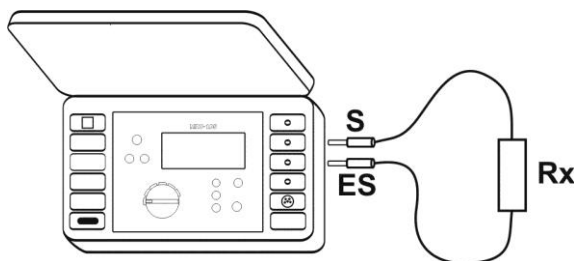


Figure 6. Two-pole method of resistance measurement

## 7.7 Four-pole Method of Resistance Measurement

The instrument enables also measurements of resistance using the four-pole technique. This can considerably decrease errors caused by test leads' resistance. This is important if the resistance measured is of a small magnitude.

1. Connect four leads to terminals **1**, **2**, **3**, **4**, labeled „H”, „S”, „ES” and „E” respectively.
2. Connect the measured resistance so that the leads hooked up to terminals „H” and „S” are both connected to one of the poles of the tested resistance, while the leads connected to terminals „ES” and „E” (Fig. 7) are hooked up to the other pole.
3. Set the rotary switch **7** to position **RE 4p**.
4. Press the button **8** **START**.
5. Read the result.

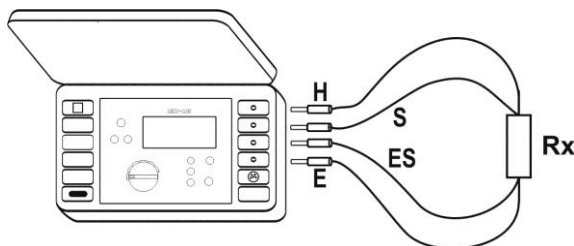


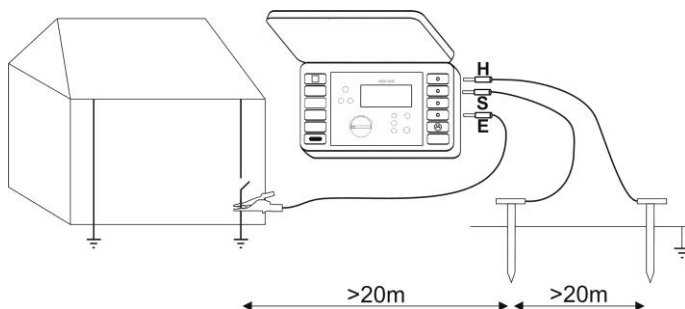
Figure 7. Four-pole method of resistance measurement

## 7.8 Earth Resistance Measurement Using Three-pole Method

The three-pole method is the most basic technique for earth resistance measurement.

1. Connect the investigated earth to socket **4** labeled as „E” (Fig. 8).
2. Connect the current electrode, driven into the soil at a distance more than 40m away from the investigated earth electrode, to the socket **1** „H” of the meter.
3. Connect the voltage electrode, driven into the soil at a distance more than 20m away from the investigated earth electrode, to the socket **2** „S”. Investigated earth electrode as well as the current and voltage electrodes should be aligned.
4. Set the rotary switch **7** to position **RE 3p**.
5. Press the key **8** **START**.
6. Read the resistance  $R_E$  measurement result and the test electrodes  $R_S$  and  $R_H$  resistances. You can toggle between values shown on the display **19** main field by repeatedly pressing the key **9** **SEL**.
7. Repeat the measurements (as in point 5 and 6) with the voltage electrode moved a few meters away and then toward the tested earth electrode. If the measurement results differ by more than 3%, the distance from current electrode to the earth electrode should be increased and the measurements repeated.

Particular attention should be paid to the condition of the contact between the tested object and the test lead. The contact point should be free from rust, paint etc.



**Figure 8. Three-pole technique for earth electrode resistance measuring**

If the resistance of the test electrodes is too high, the measurement of earth electrode resistance  $R_E$  will be burdened with an additional error. Particularly large measurement errors are observed when a small earth electrode resistance is measured with probes having a loose contact with the soil (such situation takes place when the earth electrode is correctly installed while the upper layer of the soil is dry with poor conductivity). In such conditions the ratio of electrodes' resistance to the resistance of the measured earth electrode is quite high, and so is the error depending on that ratio. You can either do some calculations (see the formula given in the appendix "Technical data") to evaluate the impact of the test conditions or you can use the graph (see the same appendix). You can also improve the contact between the electrodes and the soil e.g. by moistening the place, where the electrode sits in the ground, with some water or by moving the electrode to another location. Also, the test leads should be checked for any insulation damage and for proper contact between the lead and the banana plug (electrode must not be corroded or loose). In the majority of cases the accuracy of measurements is sufficient. However, one should be aware of the magnitude of errors present in the measurement result.

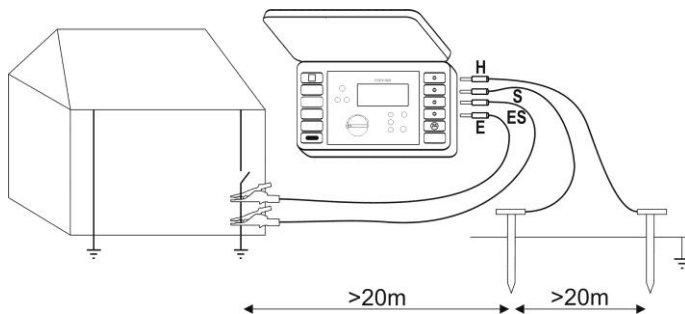
## 7.9 Earth Resistance Measurement Using Four-pole Method

If it is necessary to perform a measurement not distorted by the test leads' resistance error the four-pole method can be used.

### Note:

**For soil resistivity measurements it is recommended to use the function  $\rho$ .**

1. Connect the investigated earth electrode to sockets **3** and **4** of the meter, labeled „E” and „ES” correspondingly (Fig. 9).
2. The current electrode, driven into the ground at a distance of over 40 m from the tested earth electrode, connect to the socket **1** „H”.
3. The voltage electrode, driven into the soil at a distance of 20 m from the tested earth electrode connect to socket **2** „S”. The earth electrode investigated as well as the current and voltage electrodes should be aligned.
4. Set the rotary selector **7** to position **RE 4p**.
5. Press the key **8** **START**.
6. Read the earth electrode resistance  $R_E$  and  $R_S$  and  $R_H$  resistances of test electrodes. You can toggle between values shown on the display **19** main field by repeatedly pressing the key **9** **SEL**.
7. Repeat the measurements (as in point 5 and 6) with the voltage electrode moved a few meters away and then toward the tested earth electrode. If the measurement results differ by more than 3%, the distance from current electrode to the earth electrode should be increased and the measurements repeated.



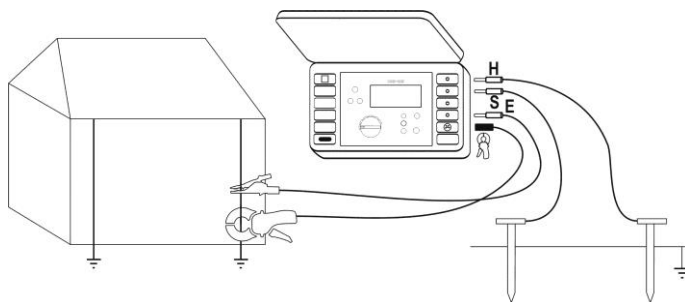
**Figure 9. Four-pole method of earth electrode resistance measurement**

## ***7.10 Multiple Earth Electrodes Resistance Measurement Without Disconnecting the Measured Ground Electrodes (using clamps)***

**Note:**

**Clamps are not a part of the standard kit, they can be purchased additionally from the manufacturer or from suppliers.**

MRU-105/MRU-106 device can be used for performing measurements of multiple earth electrodes (that is many ground electrodes connected into a single system, e.g. earth electrodes of high voltage transmission poles) without being disconnected. Test clamps are used to enable the instrument to determine what amount of the test current flows through the particular earth electrode.



**Figure 10. Measurement of the multiple earth electrodes resistance using the three-pole method**

1. Connect the investigated earth electrodes connect to terminal **4** labelled „E” (Fig. 10).
2. Connect the current electrode, driven into the ground at a distance exceeding 40 m from the investigated earth electrode, to the socket **1** „H”.
3. Connect the voltage electrode, driven into the ground at a distance exceeding 20 m from the investigated earth electrode, to the socket **2** „S”. The investigated earth electrode as well as the current and voltage electrodes should be aligned.
4. Connect the clamps to terminal **5** and attach the clamps below the point where the lead „E” is attached



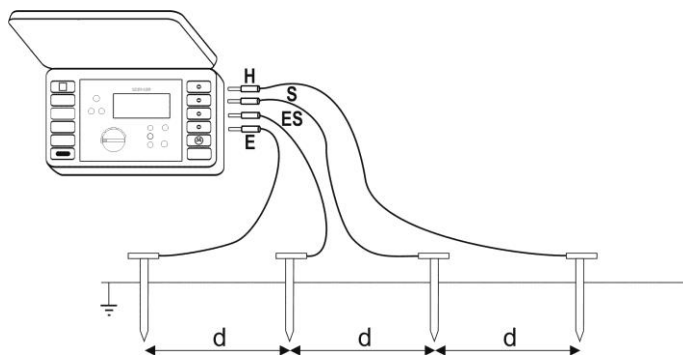
5. Set the rotary switch **[7]** to position **RE 3p 8**.
6. Press the key **[8] START**.
7. Read the earth electrode resistance  $R_E$  and the resistances  $R_S$  and  $R_H$  of the test electrodes. You can toggle between values shown on the display **[19]** main field by repeatedly pressing the key **[9] SEL**.
8. Repeat the measurements (as in point 6 and 7) with the voltage electrode moved a few meters away and then toward the tested earth electrode. If the measurement results differ by more than 3%, the distance from current electrode to the earth electrode should be increased and the measurements repeated.

When using the multiple earth electrode method to test the power line poles, there is sometimes a need to determine not only the resistance of single ground electrodes, but also the total resistance of the entire earth electrodes system. After obtaining the component measurement results  $R_{E1}$ ,  $R_{E2}$ ,  $R_{E3}$ ,  $R_{E4}$ , ... the total resistance of the system can be calculated from the formula:

$$R_E = \frac{1}{\frac{1}{R_{E1}} + \frac{1}{R_{E2}} + \frac{1}{R_{E3}} + \frac{1}{R_{E4}} + \dots}$$

## 7.11 Soil Resistivity Measurement

To measure the soil resistivity - measurements used in preparation for establishment of an earth electrodes system, or in geology – a separate function (measurement of soil resistivity  $\rho$ ) selectable with the rotary switch has been provided. From the metrological point of view this function is identical to the four-pole earth electrode resistance measurement method. However, it has an additional procedure of entering the distance between the electrodes. The result of the measurement is the soil resistivity value calculated automatically using the formula  $\rho = 2\pi d R_E$  utilised in Wenner's measurement method. This technique assumes equal distances between electrodes.



**Figure 11. Soil resistivity measurement**

1. Electrodes (driven into the soil in a straight line and at equal distances from each other) are connected to sockets **[1]**, **[2]**, **[3]** and **[4]** labelled with letters „H“, „S“, „ES“ and „E“, respectively.
2. Set the rotary switch **[7]** to position „ $\rho$ “.
3. Press the key **[8] START**.
4. The displayed distance between electrodes can be changed using the arrow keys **[11]** and **[12]**.
5. Press the key **[8] START**.

6. Read the soil resistivity, the resistance  $R_E$  (of the space between the electrodes S and ES) and the resistances  $R_S$  and  $R_H$ . You can toggle between values shown on the display **19** main field by repeatedly pressing the key **9** **SEL**.

**Note:**

**It is assumed in the calculations, that the distances between test electrodes are equal (Wenner's method). If this is not the case, the measurement of earth electrodes resistances is to be performed using the 4-pole method and the subsequent calculations have to be done independently.**

## 7.12 Measurement Results Storage

MRU-105 and MRU-106 meters are equipped with a memory that can hold 300 measurement results. A single result is saved into a location called a memory cell. Each measurement result can be saved in an arbitrarily selected cell. Consequently the user can at will assign memory cell addresses to particular measurement points, perform measurements in any sequence and repeat the measurements without losing other data.

Saved results **are not erased** after switching the meter off; therefore they can be later retrieved or transferred to a computer. Also, the current cell and bank address will not be altered.

It is recommended to erase the memory after retrieving the data or before taking a new series of measurements that can be stored in the same cells as the previous ones.

Only the earth electrode resistance  $R_E$ , and soil resistivity  $\rho$  are stored in the memory. The measured test electrodes resistance values can only be displayed on the screen immediately after the measurement has been done.

### 7.12.1 Retrieving Results from the Memory

The memory access mode can be turned on only momentarily by pressing the key **11** **▲** or **12** **▼**. The mode switches off automatically after approx. 4 seconds or after pressing either of the two keys. In the auxiliary result field **24** the current memory cell address is displayed. The memory cell contents is shown in the main result field **19**.

1. Set the cell number address to be accessed using the key **11** **▲** and **12** **▼**.
2. Read the measurement result. When two dots are displayed (symbol **27** **. .**), it means that no results are stored in the cell.






In this mode it is also possible to erase the contents of all memory cells.

### 7.12.2 Storing the Measurement Results into the Memory

The memory write mode is active from the moment it is turned on until the device is switched off or the measurement function is changed. Storing a result is possible only when the instrument displays the result of the recent measurement or one of the components of the result selected with the **SEL** key. In any case, only the main measurement result (the resistance, the earth electrodes resistance  $R_E$ , or soil resistivity  $\rho$ ) is written into the memory.


1. Turn on the memory write mode by pressing the key **10** **↔**. The auxiliary display field of **24** that shows the current memory cell address will start flashing. If in the current memory cell there is already a result stored, the memory cell number will flash alternately with two horizontal dashes.
2. Write the measurement result to the current cell pressing the key **10** **↔**. Displayed symbol **28** **[ ]** will confirm that the data was stored in the memory and the current memory cell address will be incremented by 1.


Alternately:

1. Turn on the memory write mode by pressing the key **10** . The auxiliary display field of [24] that shows the current memory cell address will start flashing. If in the current memory cell there is already a result stored, the memory cell number will flash alternately with two horizontal dashes.
2. Using the keys **11**  and **12**  select a memory cell number.
3. Write the measurement result to the current cell by pressing the key **10** . Displayed symbol **28**  will confirm that the data was stored in the memory and the current memory cell address will be incremented by 1.

Writing into the cell 300 (the last cell in the memory) is signalled with additional long audible signal, while the current memory cell number remains unchanged.

### 7.12.3 Deleting the Contents of the Memory

In the memory read mode the cell with 00 address has a special role. No data can be stored in it. However, selecting it will cause the main display field to show the symbol **29**  dEL, which signals that the meter is ready to delete the entire contents of the memory.

The instrument starts erasing the memory after the key **10**  is pressed. During the process the display will show the memory cells' addresses being erased. After all the cells have been erased the instrument emits a long audible signal and exits the memory read mode, setting the current memory cell number 1 as a default.

**Note:**

**Erasing the memory contents causes irreversible loss of the stored results.**





## 7.13 Transmitting Data to a PC

### 7.13.1 PC Connectivity Kit

To connect your MRU-105 (106) to a PC you will need an USB cable (standard equipment) and appropriate software (optional). If the software was not bought together with the device, it can be purchased from the manufacturer or from authorised distributors.

The software can be used with a number of SONEL S.A. instruments equipped with an USB port. Detailed information on the software can be obtained from the manufacturer and its distributors.

### 7.13.2 Connecting the Meter to a Computer

1. Connect the cable to an USB port of the computer and to the port **5**  of the meter.
2. If connection is made for the first time system will find appropriate driver (If software is installed). Launch the software.
3. Turn on the data transmission mode by switching the instrument on with the key **6**  while holding the key **10**  depressed until the display will show the symbol **23**  COMM. The meter remains in data transmission mode as long as it stays switched on.
4. Follow the software instructions.

## 8 Troubleshooting


### 8.1 Warnings and Messages Displayed by the Meter

MRU-105/MRU-106 instruments display warning messages that can be triggered by either malfunction of the device or by non-optimal external conditions.

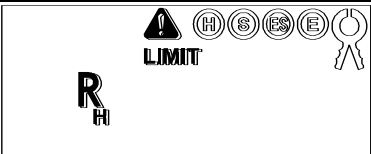
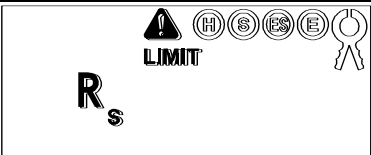
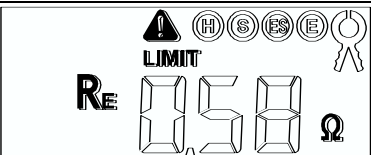
In the following figures, showing simplified images of the display the following convention is used:

- black colour for continuously displayed symbols,
- grey colour for flashing symbols,
- contoured symbol is displayed depending on the situation that caused the error.

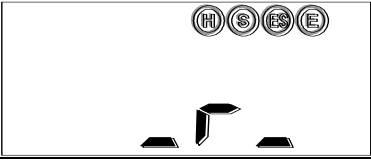
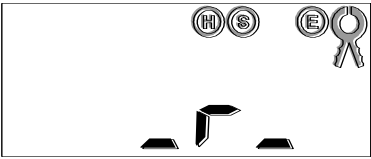
#### 8.1.1 Measurement Range Exceeded

Display Panel State	Cause	Resolution
	The resistance measured is greater than 20kΩ.	

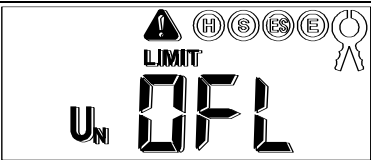
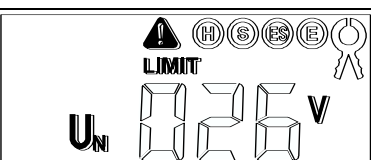
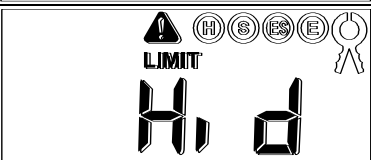
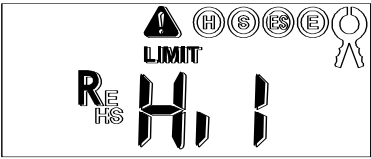
#### 8.1.2 Errors Related to the Resistance of Electrodes

Display Panel State	Cause	Resolution
	The $R_H$ electrode resistance is greater than 50kΩ.	Try to improve the contact of the electrode with soil, e.g. by moistening its surrounding.
	The $R_s$ electrode resistance is greater than 50kΩ.	Try to improve the contact of the electrode with soil, e.g. by moistening its surrounding.
	Additional measurement error due to the ratio of electrodes resistance to the $R_E$ resistance is greater than 30%	The resistance of electrodes $R_H$ and $R_s$ needs to be decreased.

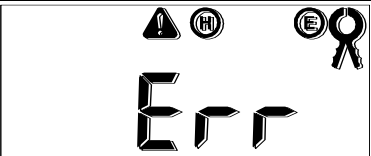
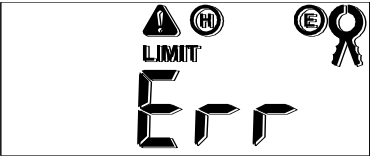


### 8.1.3 Information Related to Detected Lack of Connections' Continuity

Display Panel State	Cause	Resolution
	The instrument detected lack of continuity of the connections between the electrodes whose symbols are flashing.	Check the connections to the electrodes indicated by flashing symbols.
	The instrument detected lack of continuity of the connections between the electrodes whose symbols are flashing; if the clamp symbol flashes they might be connected incorrectly or the clamps current is too low for a successful measurement.	Check if the measurement diagram is correct. Repeat the multiply earth electrode test after disconnecting it.

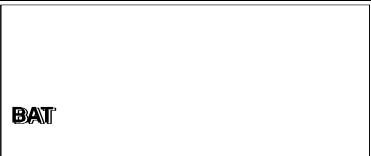
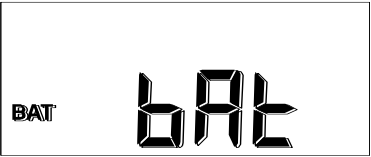

### 8.1.4 Information Related to Noises

Display Panel State	Cause	Resolution
	The noise voltage due to the distribution of the potential in the soil exceeds 40V. Measurement of soil resistance will not be possible. The meter emits an acoustic signal.	Disconnect the meter from electrodes <u>immediately</u> . Before connecting the meter again to the tested circuit switch off the source of the current.
	The noise voltage due to the distribution of the potential in the soil exceeds 24 V. Measurement of soil resistance will not be possible.	Switch off the source of the current causing the noise. Try to relocate the probes.
	Differences between subsequent measurements too large.	Check the stability (quality) of connections. The situation can also be caused by strong noises.
	During the measurement of $R_E$ , $R_H$ or $R_S$ the disturbing current too large.	Can be caused by too high equalizing currents in the tested earth electrode.

### 8.1.5 Information Related to Clamps Calibration

Display Panel State	Cause	Resolution
	Inconsistencies between subsequent measurements during clamps calibration; incorrect type of clamps or the clamps damaged.	Check quality of connections and/or replace the clamps.
	Measurement error too large after clamps calibration.	Try to calibrate the clamps again paying particular attention to placing the lead in the centre of clamps jaws.
	Current didn't flow in the lead in which the meter forces the current flow.	Check connections.
	No current in the clamps circuit.	Check the connection between the clamps and the instrument and make sure that the clamps are placed on the tested lead.

### 8.1.6 Battery Status Information

State of the display	Cause	Procedure
	Battery cells or NiMH battery package discharged.	Replace the disposable batteries, or recharge the reusable batteries.
	Batteries too low to ensure proper functioning of the device.	Replace the disposable batteries, or recharge the reusable batteries.
	Tried to charge the third party rechargeable or disposable batteries.	There is no possibility to charge disposable batteries. Build in charger is working only with battery pack– <b>WAAKU05</b>

## 8.2 Messages Informing About Errors Encountered During the Self-Test

MRU-105/MRU-106 instruments are frequently subject to strong electromagnetic fields which can have an impact on the internal registers. The device automatically checks some parameters and displays error messages:

- E10 – error in reading or writing the result and/or settings to/from the memory,
- E51 – error in voltage measurement circuit,
- E61 – error in current measurement circuit,
- E88 – error in reading the meter calibration data,
- E99 – error in the program memory of the microprocessor.



Error message can be also caused by external factors. It is therefore recommended to switch the device off and then on. If the problem persists, send the device to an authorised service agent.

## 8.3 Before You Send the Device for Repairs.

Before you send the device to a service agent, you should contact the technical support to ensure that the problem is a result of a fault and is not caused by some other factors.

All repairs should be conducted only by service agents authorised by the manufacturer.

In the table below you will find the procedures that should be followed in a case of malfunction:

Symptom	Cause	Procedure
The meter doesn't switch on when the key  is pressed	Batteries discharged or improperly inserted; NIMH battery package discharged	Check if the batteries are inserted properly or replace the disposable batteries; recharge the reusable batteries. If the problem persists, send the meter to the service.
The symbol „BAT” is displayed		
The symbol  is displayed and the instrument switches off automatically		
Fuzzy and random display of screen fragments		
During data transmission no communication can be established or communication is not error free	In the configuration program a meter with an incorrect code has been selected	Configure the program for the correct meter
	The transmission cable plug not fully connected to the meter's port	Correct the connection of the meter to the computer
	The USB cable damaged	Check the cable, replace if necessary
	USB port damaged	Repair the computer

# 9 Cleaning and maintenance

## CAUTION!

Use only maintenance methods recommended in this booklet by the manufacturer.

The housing of the meter should be cleaned with a soft, damp cloth using a general-purpose detergent. Do not use any solvents or any abrasive cleaning agents.

Probes can be washed with water and dried out. Before storing for a prolonged period of time it is recommended to apply to the probes any kind of machine grease.

Reels and test leads can be cleaned using water with some detergent added and then dried out.

Cover can be washed at a temperature not exceeding 40°C, using standard washing products. Do not dry clean or iron.

Electronic circuitry of the meter is maintenance free.

# 10 Decommissioning and Recycling

Decommissioned electrical and electronic equipment should be collected separately from any other types of waste.

Decommissioned electronic equipment should be sent to a recycling depot in conformance with waste management guidelines.

Do not remove any components from electronic equipment before sending it to a waste depot.

Local legislation and guidelines regulating disposal of packaging and batteries should be followed.

# 11 Appendices

## 11.1 Technical Specifications

- „dv.” in the description of the basic error denotes the displayed value.

### Measurement of earth electrode resistance without using clamps

Method used: voltage and current measurement using probes in accordance with IEC 61557-5

Measurement range in accordance with IEC 61557-5: 0.13Ω ... 20.0kΩ

Range	Resolution	Basic error
0.00...9.99 Ω	0.01 Ω	±(3% dv. + 3 digits)
10.0...99.9 Ω	0.1 Ω	±(3% dv. + 2 digits )
100...999 Ω	1 Ω	±(3% dv. + 2 digits )
1.00...9.99 kΩ	0.01 kΩ	±(3% dv. + 2 digits )
10.0...20.0 kΩ	0.1 kΩ	±(3% dv. + 2 digits )

- Additionally, errors due to probes' resistance (as per formula below) should be considered:

$$\delta_{dod} = \pm \left| \frac{(R_H - 100\Omega) \cdot (R_S + 30000\Omega)}{R_E} \cdot 5 \cdot 10^{-7} + (R_H - 100\Omega) \cdot 10^{-4} \right| \quad [\%]$$

where  $R_E$ ,  $R_H$  and  $R_S$  are the values displayed by the meter in [Ω]. The factor used in the formula above ( $5 \cdot 10^{-7}$ ) is expressed in [1/Ω].



## Earth electrode resistance measurement using clamps

Method used: voltage and current measurement using probes in accordance with IEC 61557-5 and current measurement in a single circuit branch using a current transformer (clamps)

Measurement range in accordance with IEC 61557-5: 0.16Ω ... 20.0kΩ

Range	Resolution	Basic error
0.00...9.99 Ω	0.01 Ω	±(8% dv. + 3 digits )
10.0...99.9 Ω	0.1 Ω	±(8% dv. + 2 digits )
100...999 Ω	1 Ω	±(8% dv. + 2 digits )
1.00...9.99 kΩ	0.01 kΩ	±(8% dv. + 2 digits )
10.0...20.0 kΩ	0.1 kΩ	±(8% dv. + 2 digits )

- Additionally, errors due to the probes' resistance (as per the formula above) should be considered. In the case of a multiple earth electrodes, the resultant earth resistance measured without clamps should be substituted for  $R_E$ . Also an error resulting from the ratio of the tested circuit resistance to the resultant resistance (calculated using the formula below) should be taken into account.

$$\delta_{dod} = \pm 0.03 \cdot \frac{R_C}{R_W^2} \quad [\%]$$

where  $R_C$  is the value measured using clamps and displayed by the meter and  $R_W$  is the resultant resistance value (both measured in [Ω]). The factor used in the formula above (0.03) is expressed in [Ω].

## Measurement of soil resistivity

Method used: voltage and current measurement using probes in accordance with IEC 61557-5

Range	Resolution	Basic error
0.00...9.99 Ωm	0.01 Ωm	In dependence of uncertainty of $R_e$ measurement using four electrodes, but no less than ±1 digit
10.0...99.9 Ωm	0.1 Ωm	
100...999 Ωm	1 Ωm	
1.00...9.99 kΩm	0.01 kΩm	
10.0...99.9 kΩm	0.1 kΩm	
100...999 kΩm	1 kΩm	

- Errors listed above do not take into account an error due to electrodes' resistance, calculated from the above formula.
- Additionally, errors due to probes' resistance (as per the formula above) should be considered.

## Measurement of auxiliary electrodes' resistance $R_H$ and $R_S$

Measurement errors of $R_S$ and $R_H$ resistances when not using clamps
±5% of the total of the displayed values ( $R_E + R_S + R_H$ )

Measurement errors of $R_S$ and $R_H$ resistances when using clamps
±10% of the total of the displayed values ( $R_E + R_S + R_H$ )

## Noise voltage measurement DC + AC

Measurement method: full wave rectification

Internal resistance: approx. 2MΩ

Range	Resolution	Basic Error
0...40 V	1 V	±(10% w.w. + 1 digit)

## Other technical data

- a) Insulation type ..... double, EN 61010-1 and IEC 61557 compliant
- b) Metrological category ..... III 300V (< 2000m above sea level), III 260V (< 3000m above sea level) EN 61010-1 compliant
- c) Housing protection class in accordance with EN 60529..... IP54
- d) Maximum noise voltage AC + DC, at which the measurement is still performed..... 24V
- e) Maximum measured noise voltage ..... 40V
- f) Maximum resistance to noise current ..... max 3.3A 50Hz
- g) Test current frequency..... 128 Hz (MRU-105, fn=50Hz), 154Hz (MRU 106, fn=60Hz)
- h) Test voltage..... 30V
- i) Test current ..... 225mA
- j) Maximum resistance of the test probes ..... 50kΩ
- k) Clamps low current warning..... 0,5mA
- l) Device power supply..... rechargeable battery pack SONEL NiMH 7,2V 3Ah  
..... or alkaline disposable batterie R14 (5x)
- m) Charger power supply..... 100...250V/50(60)Hz, 100mA
- n) Batteries charge time ..... approx. 3 hours
- o) Batteries discharge time in the discharge mode ..... max 3 hours
- p) Number of measurements that can be performed with one set of alkaline batteries (on average)  
..... 2600 (5Ω, 2 measurements/min)
- q) Number of measurements that can be performed with one set of rechargeable batteries.....  
..... 1300 (5Ω, 2 measurements/min)
- r) Time required to perform a measurement of:
  - resistance using the two-pole technique ..... <8 seconds
  - resistance using the four-pole technique ..... <16 seconds
  - earth electrodes resistance using the three-pole and four-pole method ..... <16 seconds
  - earth electrodes resistance using the three-pole method with clamps ..... <20 seconds
  - soil resistivity ..... <16 seconds
- s) Dimensions ..... 295 x 222 x 95 mm
- t) Mass of the meter with a NiMH battery pack ..... approx. 2kg
- u) Operating temperature range..... 0...40°C
- v) Humidity ..... 20...80%
- w) Battery charging temperature ..... +10...+35° +23 ± 2°C
- x) Storage temperature..... -20°C...+60°C
- y) Idle time to auto-off..... 2 minutes
- z) Quality standard ..... design and manufacturing ISO 9001 compliant

## 11.2 Manufacturer

The manufacturer of the device provides all warranty and after-warranty repairs:

**SONEL S.A.**  
ul. Wokulskiego 11  
58-100 Świdnica  
Poland  
tel. +48 74 858 38 60  
fax +48 74 858 38 09  
E-mail: [export@sonel.pl](mailto:export@sonel.pl)  
Web page: [www.sonel.pl](http://www.sonel.pl)

**Note:**  
**Service repairs can be carried out only by the manufacturer.**





**SONEL S.A.**  
**Wokulskiego 11, St**  
**58-100 Swidnica**  
**Poland**



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